REMARKS/ARGUMENTS

Independent claim 1 has been amended to point out explicitly that the amplifier output is connected to the pixels to be actively coupled to pixel reset transistors during a pixel reset phase. Claim 1 has further been amended to point out that the amplifier output is connected to pixels to provide a negative feedback signal to a selected pixel during the pixel reset phase.

Claims 13 and 25 have been amended to point out explicitly that the amplifier is connected to provide a negative feedback signal to reset transistors during a pixel reset phase.

No new matter has been added by these amendments. On page 7, lines 21++ of the instant application there is described the "reset phase" of a pixel. During the reset phase, the gate on a pixel reset transistor is brought to a "high" signal level to enable a unity gain negative feedback loop including the pixel reset transistor, the amplifier, the pixel source follower transistor, and the pixel row select transistor; the reset transistor is actively coupled to the amplifier in this feedback loop during the reset phase.

Recitation of the Invention as-claimed:

The invention, as recited in amended claim 1, is directed to an image sensor. The image sensor includes a plurality of pixels which each have an output and a first circuit that produces a signal proportional to incident light intensity. This first circuit is connected to supply the proportional signal to the pixel output. Each pixel also includes a select node connected to receive a select signal for selecting a given pixel from the plurality of pixels, and each pixel includes a reset transistor for resetting the pixel.

The image sensor further includes an amplifier which has a first input for receiving outputs of the pixels. The amplifier also has an output that is connected to be actively coupled to the reset transistor of each pixel during a pixel reset phase. This active coupling of the amplifier output to the reset transistors enables the amplifier to provide a negative feedback signal to a selected pixel during the pixel reset phase. A reset reference voltage source is connected to apply a reset reference voltage signal to the amplifier to provide a voltage reference for controlling reset of pixels.

Rejections of the Claims:

Claims 1-40 were rejected under 35. U.S.C. §102(e) as being anticipated by Kozlowski et al., U.S. Patent No. 6,532,040. The Examiner suggested that Kozlowski teaches a configuration of a plurality of pixels, with one pixel indicated by the dotted box in Fig. 3. The pixel of Kozlowski Fig. 3 is said to include an output, V_n, and to include a circuit that produces a signal proportional to incident light intensity, with the circuit connected to supply the proportional signal to the pixel output. The Examiner indicated that transistor M3 in Kozlowski Fig. 3 is a reset transistor for resetting the pixel. The Applicant agrees with this characterization of the Kozlowski pixel.

The Examiner goes on to suggest that Kozlowski also shows an amplifier (50) in Fig. 3, having a first input for receiving the output, V_n, of the pixel. Kozlowski's amplifier is suggested by the Examiner to have an output that is coupled to the reset transistor of the pixel to provide a negative feedback signal to a selected pixel.

The Examiner stated that Kozlowski's amplifier output is coupled to the pixel reset transistor M3 through the transistor M4. The Examiner further stated that such a "coupling" of the amplifier output to the pixel reset transistor does not require a direct connection.

For any definition of "coupling" or "connection," the Applicant submits that Kozlowski's configuration fails to meet the requirements of the claims as-amended. Specifically, Kozlowski does not teach or suggest a configuration in which an amplifier output is connected to pixels to be actively coupled to pixel reset transistors during the pixel reset phase. Kozlowski further fails to teach or suggest an amplifier output connection that provides a negative feedback signal to a selected pixel during the pixel reset phase.

Claim 1 has been amended to make explicitly clear and to explicitly require that in accordance with the invention, the amplifier output is connected to pixels to be actively coupled to the pixel reset transistors during the pixel reset phase, to provide a negative feedback signal to a selected pixel during the pixel reset phase.

To aid in a discussion of the Kozlowski pixel amplifier configuration, Fig. 3 of Kozlowski and Fig. 2 of the instant application are reproduced below.

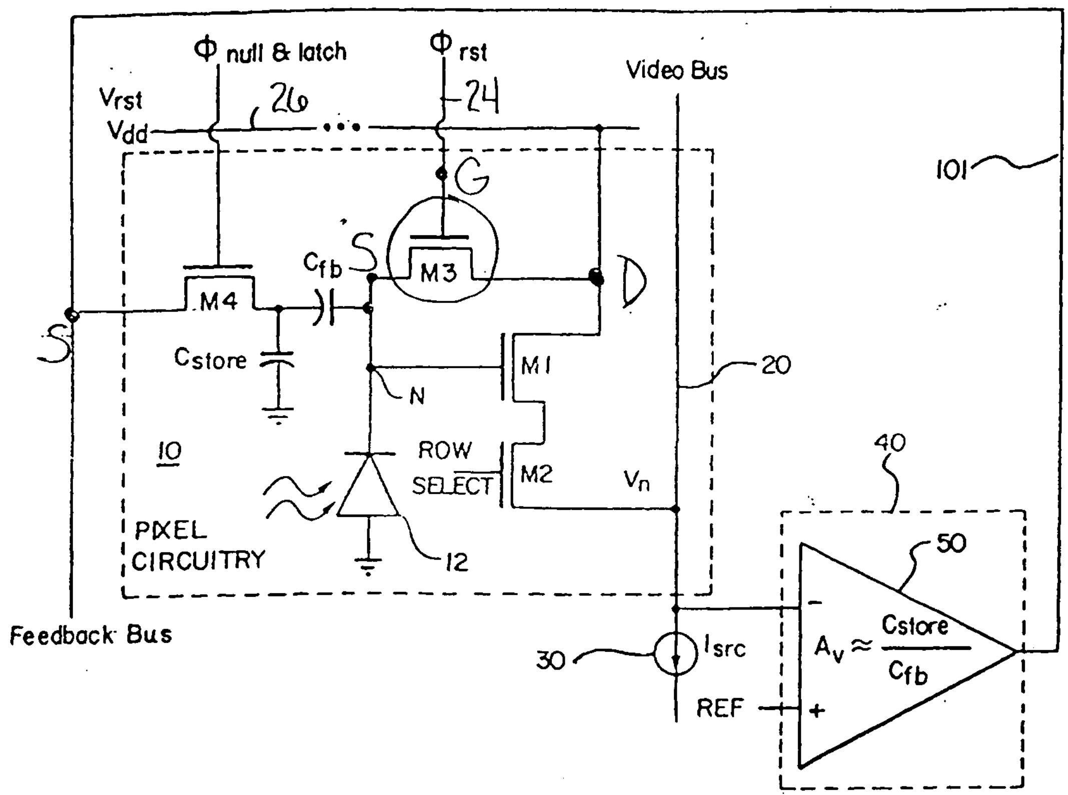

FIG. 3 KOZLOWSKI

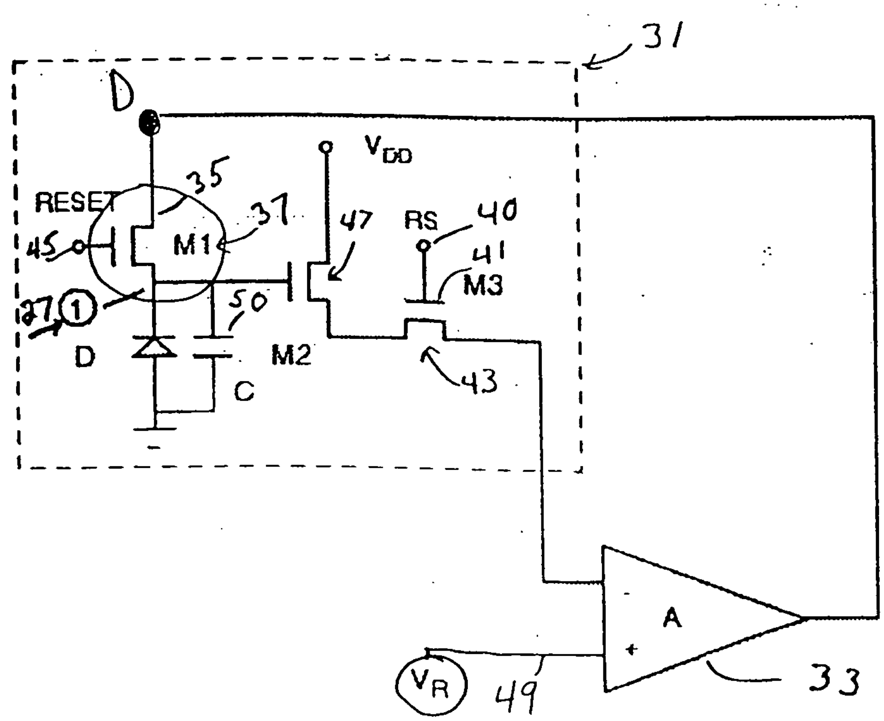

Fig. 2 INSTANT APPLICATION

In Kozlowski's pixel, the reset transistor, M3, has been circled. The source, S, gate, G, and drain, D, of the reset transistor M3 are labeled for reference, as given by Kozlowski Fig. 2. The gate G of the reset transistor M3 is connected to a reset clock Φ_{rst} - specifically, a row or column bus 24 (Fig. 2) connects the gate G of M3 to the reset clock (col. 7, lines 17-19). The drain of the reset transistor M3 is connected to a row reset supply voltage V_{rst} - specifically, a row bus 26 (Fig. 2) connects the drain D of M3 to a reset supply voltage (col. 7, lines 19-21). The source of the reset transistor M3 is connected to the cathode node N of the photodiode 12 and a capacitor C_{fb} of a sample-and-hold circuit.

In operation of the Kozlowski imager, when a pixel is reset, the reset clock voltage Φ_{rst} is applied to the gate G of reset transistor M3, turning "on" the reset transistor, to enable connection of the reset voltage V_{rst} through the reset transistor to the cathode N of the photodiode 12. This clears the photo-induced charge from the photodiode (col. 8, lines 15-22). During this reset phase, the feedback amplifier 50 is not engaged, and is not in any way connected to be able to deliver signals to the pixel. The null and latch transistor M4 is held "off," disabling any coupling of the amplifier output to the pixel. In other words, there is no feedback from the amplifier to the pixel during the pixel reset phase.

Then after the pixel is reset, the reset transistor M3 is turned "off", and the feedback amplifier 50 is engaged to "null out the noise" of the pixel value (col. 8, lines 61-62). During this process, the null and latch clock voltage $\Phi_{null\&latch}$, is applied to turn "on" transistor M4, so that a feedback loop is closed, with the output of the amplifier applied to the source S of transistor M4. With transistor M4 turned "on" this output is applied through the transistor M4 to the storage capacitance, C_{store}. The stored capacitance is then coupled through the coupling capacitor C_{fb} to the integrating node N of the photodiode 12. This is the process described at col. 8, lines 23-42 referred to by the Examiner.

The reset transistor M3 is turned "off" during the noise null-out phase, and is therefore not in any way active or "on" during the process. The feedback loop applies a voltage to the integrating node N of the photodiode through the null and latch transistor M4 that is entirely separate from the reset transistor M3 and M3 makes no part of the loop.

Kozlowski's amplifier connection thereby results in the following reset transistor state and the amplifier output state during Kozlowski's reset and null-out phases:

	Reset Phase	Null-Out Phase
Reset Transistor:	Active	Inactive
Amplifier Output:	Inactive	Active

Claim 1 as-amended requires that the amplifier output be connected to pixels to be actively coupled to reset transistors during the pixel reset phase. From the above it is clear that during Kozlowski's reset phase, his amplifier output is not actively coupled to a reset transistor. Instead, Kozlowski employs a blocking null and latch transistor, M4, that is held "off" during the reset phase to ensure that his amplifier output is not coupled to the pixel at all, let alone actively coupled to the reset transistor.

Claim 1 as-amended further requires that the amplifier output be connected to provide a negative feedback signal to a selected pixel during the pixel reset phase. Claims 13 and 25 as-amended require that the amplifier be connected to provide negative feedback to a reset transistor during a pixel reset phase. Again, from the above it is clear that during Kozlowski's reset phase, his amplifier output is blocked from coupling to the pixel. There is no connection that could enable a feedback signal to be delivered by the amplifier output to the pixel during the pixel reset phase. Instead, Kozlowski's amplifier output is connected, via the null and latch transistor M4, so that after the reset phase, when the reset transistor is

turned "off" and is not active, Kozlowski then engages the amplifier output by turning "on" the null and latch transistor M4 and then providing a negative feedback signal to the pixel. But the amplifier output is connected so that during Kozlowski's reset phase, no negative feedback signal is delivered to the pixel.

In contrast, as shown in Fig. 2 above from the instant application, in the pixel configuration provided by the invention, the output of the amplifier 33 is connected to the drain D (35) of the reset transistor M1 (37). In operation, during the pixel reset phase, the reset transistor M1 is turned "on" by applying a corresponding voltage to the gate 45 of the reset transistor. At the same time, the output of the amplifier is connected through the reset transistor to the node 1 of the photodiode D. The output of the amplifier is thus actively coupled to the reset transistor during the pixel reset phase. With this connection, the output of the amplifier delivers a negative feedback signal to the pixel during the pixel reset phase.

This pixel design and operation provided by the invention overcomes the limitation of the Kozlowski design in that it dramatically reduces the number of devices required to be included in a pixel. The Kozlowski design employs a conventional sample-and-hold circuit design, including the transistor M4 and capacitors C_{store} and C_{fb} to apply an offset voltage to the photodiode node N. The Applicant has discovered that this circuit can be eliminated and instead the output of an amplifier actively coupled to the reset transistor for applying an offset voltage to the node of the pixel photodiode during the reset process. The entire sample-and-hold circuit employed by Kozlowski is eliminated by the pixel design of the invention.

In addition, Kozlowski requires a second phase, after a pixel reset phase, to apply an offset voltage through his sample-and-hold circuit to the photodiode node N (col. 9, lines 46-62). But in the invention, by actively coupling the amplifier output to the reset transistor, an offset voltage can be applied during the reset

phase itself, without the need for an additional step. The efficiency and speed of the pixel operation is therefore substantially improved by the pixel configuration of the invention.

The Applicant respectfully submits that with this discussion of the Kozlowski pixel configuration and operation, it is abundantly clear that the output of the Kozlowski amplifier is not actively coupled to the reset transistor of the Kozlowski pixel during a pixel reset phase as required by the claims, and that the Kozlowski amplifier output is not connected to provide a negative feedback signal to a selected pixel during the pixel reset phase as required by the claims.

Independent claims 13 and 25 also specifically require that the amplifier be connected to provide a negative feedback signal to the reset transistor during the pixel reset phase. As is now clear, no feedback signal is provided to the reset transistor in Kozlowski's pixel. Like claim 1, claims 13 and 25 require a pixel configuration that eliminates the sample-and-hold circuit of Kozlowski, in which a feedback signal is provided to a sample-and-hold transistor M4 rather than to a reset transistor.

The Examiner suggested that Kozlowski teaches a reset reference voltage source, REF, that is connected to apply a reset reference voltage signal to the amplifier to provide a voltage reference for controlling reset of pixels. Based on the discussion above, the Applicant submits that it is clear that such is not the case. The reference voltage source employed by Kozlowski is selected solely to normalize the offset signal of the pixel (col. 8, lines 40-41). Because Kozlowski's pixel configuration requires that pixel reset be carried out in a first, separate, previous step, prior to offset cancellation, the reference voltage does not play a role in control of pixel reset as required by the claims. In contrast, in the invention, the voltage reference is employed for controlling reset of pixels. Such cannot be accomplished by the Kozlowski pixel design.

Thus, the Applicant respectfully submits that Kozlowski fails to teach or even suggest the pixel design of the invention as recited in independent claims 1, 13, and 25.

Referring to claims 2, 14, and 26, the Applicant submits that while Kozlowski's amplifier includes a second input for receiving a reset reference voltage signal, Kozlowski's pixel design fails to meet the other requirements of the claims, as explained above.

Referring to claims 3, 15, and 27, the Examiner suggested that a first terminal of Kozlowski's reset transistor M3 is connected to receive a negative feedback signal to adjust a second terminal voltage of the transistor to a selected reset voltage. As explained above, this cannot be the case. Kozlowski's reset transistor M3 is not in any way connected to the feedback loop and cannot receive a negative feedback signal during the reset phase. There simply is no connection from the feedback loop to the reset transistor M3. Further, the reset transistor M3 is turned "off" when the feedback loop is engaged, and thus could not adjust the voltage at its terminals; it is simply inactive during that time.

Referring to claims 4, 16, and 28, as well as claims 5, 17, and 29, requiring the reset reference voltage source signal selection, the Examiner referred to Kozlowski Col. 7, lines 1-34. This passage describes the reset voltage, V_{rst}, and power supply voltage, V_{dd}, applied to the drain of the reset transistor M3, but no discussion of the voltage REF is supplied at any point - Kozlowski is completely devoid of any teaching of specific selection of the voltage REF and the Examiner has mischaracterized this Kozlowski passage.

Referring to claims 5, 17, and 29, requiring a ΔV selection of greater than about one hundred millivolts to maintain the reset transistor in a subthreshold operating region, the Examiner pointed to Kozlowski Col. 8, lines 15-22. As just explained, Kozlowski is devoid of any description with regard to a reference voltage,

let alone a voltage that maintains the reset transistor in a subthreshold operating region. The Examiner appears to have mistakenly referred to this Kozlowski passage, which makes no mention whatsoever of a reference voltage or a one hundred millivolt voltage.

Referring to claims 6, 18, and 30, as well as claims 7, 19, and 31, requiring a configuration of a row select transistor and a source follower transistor, the Applicant agrees with the Examiner's characterization of Kozlowski's transistors M1 and M2 as such. But even so, Kozlowski's pixel design remains devoid of the amplifier connections and reference voltage source signal required by these claims.

Referring to the remaining claims, 8, 11, 20, 23, 32, 35, 9, 21, 33, 10, 12, 22, 24, 34, 36, 37, 38, 39, and 40, all of these claims depend from one of the independent claims 1, 13 or 25. In the interest of brevity, each of these claims will not be discussed in turn. All of these dependent claims include the limitations of the independent claims, as discussed above. Kozlowski fails to teach or even suggest the pixel configuration required by the independent claims, and no additional limitations, like those of the dependent claims, provide the missing requirements.

The Applicant therefore submits that the claims are in condition for allowance, which action is requested. If the Examiner has any questions or would like to discuss the claims, he is encouraged to telephone the undersigned Agent directly at his convenience at the phone number given below.

Respectfully submitted,

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